THIRD QUARTERLY REPORT

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Texas Institute for Rehabilitation and Research
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This third quarterly report of Contract NsR 44-024-006, entitled "Development of Computer Technology for Medical Data Analysis to be Applied to Project Apollo and Follow-on Space Missions," by application of techniques to compute, display, and report on data associated with the interpretation of selected Gemini flight experiments, shall describe the general status of the work accomplished. The first and second quarterly project reports have presented a detailed documentation of the planning of analyses and the work accomplished for the first and second quarters of this contract. At this time, the work is continuing as is defined in these previous reports, and technical reports are being prepared to document the results.

The ultimate goal of these studies is to provide a meaningful presentation and interpretation of data from selected experiments on Project Gemini to help plan for medical experimentation and medical evaluation procedures for use in Project Apollo and Follow-on Space Exploration programs involving man in space. The five Gemini experiments to which attention has been directed are as follows:

1. Gemini Experiment M-1: Cardiovascular Reflex Conditioning Experiments, Extremity Cuffs

2. Gemini Experiments M-6 and M-7: Bone Densitometry and Inflight Calcium and Nitrogen Balance Studies

3. Operational Experiment: Tilt Table Studies

4. Operational Experiment: Analysis of Inflight Physiological Data

5. Blood Volume Data

Each of these five experiments associated with manned space flight have been approached separately by preparing a problem definition sheet which provides a logical, analytical approach designed to achieve the desired goals. These problem definition sheets have been discussed in detail in the preceding quarterly contract reports. For the present, each of the experiments will be discussed in terms of the data that have been acquired for application of the techniques described in the problem definition sheets. In addition, problems encountered in carrying out the work will be discussed. Finally, five separate reports will be written describing the findings of this study. Where applicable, the correlation of data from one experiment to the data in another experiment will be discussed.

A separate general report is being prepared to discuss the problems encountered and the general recommendations that are made for future experiments and data analysis.

The final reports on the analysis of each experiment will include the following:

1. Background - This section will include the theoretical background of the experiment, giving a concise description of ground and flight observations which led to the design of the experiment.

2. Statement of Problem - This section will define the anticipated or proposed problems as related to the space flight situation and the method in which the experiment will answer or prevent these problems.

3. Procedures - This section will include a complete but concise description of the experimental design. It will discuss measurements made, constraints upon making additional seemingly required measurements, and the quality of data collected.

4. Analysis - This section will describe the data identification techniques applied, the statistical and analytical approaches used in the analysis of data, the types of displays (graphic, tabular, etc.) and the means for setting up the techniques for the analysis of flight data.

5. Results - This section will present the data to the extent to which analytical techniques may be applied to achieve meaningful information. This section will be subdivided to include the detailed analyses which have been performed on selected ground-based data that will help in the interpretation of flight data.

6. Conclusions - This section will present a discussion of the physiological and medical implications of the observations made and the analyses performed. Included will be the conclusions based on both ground studies and flight studies.

7. Recommendations - This section will present an over-all and multi-disciplinary evaluation of the approach to the experimental design, collection of data, statistical manipulation, and computer processing which can be applied to future experiments involving the study of man in space.

The following sections describe the general status of the data to be used in the five technical reports that are in progress.

CARDIOVASCULAR REFLEX CONDITIONING EXPERIMENT
EXTREMITY CUFFS

1. The tilt table and plasma volume data collected on Gemini astronauts participating in experiment M-1 have been obtained.

2. Inflight data as recorded on magnetic tape recorders have been obtained on the astronauts on which extremity cuffs were used. The IRIG B time code identification of this data has been unsatisfactory, and automatic retrieval of the data has been impossible. Further, the flight logs did not provide adequate information to define the times of inflation and deflation of the cuffs to determine any acute changes or trends occurring during the mission.

3. A literature review has been performed to collect all information pertinent to the cuff experiment.

4. An extensive evaluation has been made of the tilt table and plasma volume measurements from bedrest and water immersion studies already conducted in evaluation of cuffs to prevent cardiovascular deconditioning. Included in this analysis have been the evaluation of the data on the following:

a. Four subjects participating in two 6 hour water immersion experiments with and without extremity cuffs

b. Ten subjects participating in three 10 day bedrest studies with and without lower extremity cuffs

c. Nine subjects participating in water immersion experiments of 12 hours duration using different cuff configurations and timing cycles

d. Eight subjects participating in eight separate 12 hour water immersion experiments using different cuff configurations and inflation-deflation cycles

e. Six subjects participating in three bedrest periods of 14 days duration to evaluate the effectiveness of different cuff configurations

BONE DENSITY AND INFLIGHT CALCIUM AND NITROGEN STUDIES

1. The bone density data collected in association with Gemini flights on which these studies were performed has been obtained. Included are data from two astronauts on flights GT-IV, GT-V, and GT-VII.

2. The results of the calcium balance and nitrogen balance studies recently have been obtained from the only flight, GT-VII, on which this data was collected.

3. A statistical definition and evaluation has been made of the reproducibility of the X-ray bone densitometry technique and instrumentation used in the analysis of the flight data. Ten separate films of the os calcis of one individual were analyzed using ten separate determinations with the bone densitometer.

4. A statistical definition has been determined of the day-to-day changes in the X-ray bone density on a group of individuals in ground-based studies using controlled diets prior to bedrest recumbency.

5. Detailed statistical and computer analyses have been performed on calcium, nitrogen, and related data collected from a prolonged bedrest recumbency to determine appropriate analytical techniques to apply to flight data to aid in the interpretation of observations made.

TILT TABLE STUDIES

1. Tilt table studies performed on astronauts before and after Gemini flights GT-IV, GT-V, and GT-VII have been obtained and analyzed. Data collected on flights after GT-VII have not been made available, although these data have been requested.

2. Graphic and tabular displays have been made of the raw and average data collected from these studies.

3. Statistical and computer techniques have been established for the evaluation of cardiovascular deconditioning as evidenced in the tilt table measurements collected before and after bedrest, water immersion, and space flight.

4. Extensive data have been obtained from numerous ground-based experiments to evaluate possible circadian variations on tilt response, subject-to-subject variation, characteristics of deconditioning from water immersion and bedrest, and the effectiveness of different treatment measures in preventing cardiovascular deconditioning.

BLOOD VOLUME DATA

1. The plasma volume, red cell mass, and hematocrit data obtained from the Gemini space flights GT-IV, GT-V, and GT-VII have been obtained.

2. An extensive evaluation has been made on the reproducibility of the plasma volume techniques utilizing ground-based studies on 12 subjects who had repeated plasma volume measurements.

3. A comprehensive literature survey of bedrest, water immersion, and other applicable simulation studies has been performed to provide a baseline information on the limits which must be applied to the interpretation of flight data.

4. An attempt is being made to evaluate the relation of plasma volume changes during simulated studies to tilt table intolerance after the deconditioning experiments.

In general, attention has been directed to the analysis of data from ground-based experiments for the development of computer programs and displays applicable to the space flight data. This approach has been particularly important in determining the limitations of data analysis techniques, experimental techniques, and interpretations which could be applied to the small number of subjects in the evaluation of the flight data. The specific problems in the interpretation of data from any of the above Gemini flight experiments or associated simulation studies performed to predict the changes from these flight experiments will be discussed separately in the final reports now being prepared on each of these topics.

Considerable attention has been directed toward the application of computer technology developed in medical data analysis by this research group into the operational requirements of the NASA-MSC Real Time Monitoring System which is anticipated for use in the collection, computation and display of biomedical data acquired in association with the forthcoming Apollo flights. Numerous meetings have been held with NASA medical personnel, NASA computer personnel, and NASA engineering personnel to help define appropriate techniques to gain and display the most meaningful information. Particular attention has been directed toward finding the most appropriate ways to collect, process, and display the data in order that it may provide the most useful information to the medical monitors, and thus be an integral part of the NASA Real Time Monitoring System. Such problems as astronaut identification, parameter identification, logging of events, data storage and retrieval, appropriate summaries of data, and improvement of signal-to-noise ratio (information content) of collected data have been discussed at these meetings.

The work performed to date has been accomplished through the cooperative efforts of the Texas Institute for Rehabilitation and Research, the staff of the Biomathematics Department of The University of Texas M. D. Anderson Hospital and Tumor Institute, and the staff of the many divisions of the Manned Spacecraft Center and NASA Headquarters. There has been extensive, non-cost utilization of the M. D. Anderson SDS 930 computer and associated digitizing equipment (supported partially through NIH Grant FR 00258) and the Common Research Computer Facility IBM 1410-7094 computers (supported under sponsorship of NIH Grant FR 00254). Data for bone densitometry studies have been obtained from independent investigations conducted by Dr. Pauline Beery Mack of Texas Woman's University, Denton, Texas, under Contract NsG-440. Data for reproducibility studies have been obtained from plasma volume determinations conducted in association with Dr. Philip C. Johnson, Department of Medicine, Baylor University College of Medicine. Tilt table data have been utilized which have been collected under NASA Contracts NAS 9-1461 and NAS 9-5821 to provide ground-based data for development of analytical and statistical techniques. Data collected by personnel of the NASA in association with the past Gemini flights have been used in evaluating the results of the Gemini experiments in assessing the appropriate techniques for evaluating changes that must be applied to physiological measurements for Project Apollo and Follow-on Space Missions.

It has become obvious that it is necessary to establish a very close and cooperative effort between all groups collecting data and analyzing it, for both ground-based and baseline studies so that the most appropriate and accurate final interpretation can be made of data acquired from each flight. Particular attention must be directed toward definition of hypotheses of changes that may result during space flights; the definition of these hypotheses can come most appropriately from critical evaluation of ground-based and flight experiments that have been conducted to date. A very accurate interpretation will be necessary in the planning for successive and more prolonged missions in the Apollo and Follow-on Space Missions to provide appropriate evaluations of the effects of space on man and to determine means to prevent any undesirable physiological changes that might occur.